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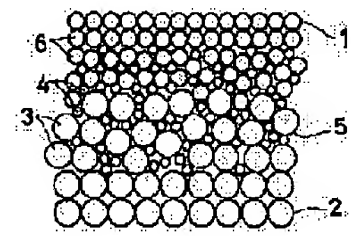
(54) SLIDING MEMBER AND ITS PRODUCTION

(57)Abstract:
PURPOSE: To improve the adhesion property of a substrate to a diamond like carbon(DLC) film formed on the surface of the substrate and to obtain a sliding member small in frictional force by forming a mixing layer of carbon atom with an implanting atom on the boundary part between the DLC film and the substrate.
CONSTITUTION: The DLC film 2 of the amorphous diamond like carbon is formed on the surface of the substrate 1, and after ions are implanted by ion implantation method. As a result, the mixing layer 5 of carbon atom 3 with the implanting atom 4 is formed on the boundary part between the substrate 1 and the DLC film. Then, the sliding member in which the mixing layer 5 is formed on the boundary part is obtained and the adhesion property of the substrate 1 to the DLC film 2 is improved and the frictional force becomes small. The stripping of the DLC film 2 is prevented because the difference of coefficient of thermal expansion between the substrate 1 and the DLC film 2 is absorbed by the mixing layer.



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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to a moving part and its manufacture method.
[0002]
[Description of the Prior Art] Various kinds of moving parts are contained in the measuring instrument used in the clean environment of vacuum atmosphere, activity and inert gas atmosphere, a clean room, etc., a manufacturing installation, and input/output equipment in each nose-of-cam field, such as a semiconductor, medicine, and a spacecraft machine. As such a moving part, the bearing parts of anti-friction bearing are known, for example. In anti-friction bearing, it is not avoided at the time of use that a skid occurs between a bearing washer and a rolling element. By the way, as a moving part used in a clean environment which was mentioned above, it is required not to mention the frictional force in the case of use being small that especially the amount of raising dust should be very small.
[0003] That in which the hard carbon film called the diamond-like carbon (DLC) film amorphous on the surface of a base material as a moving part which filled such a demand conventionally was formed is considered.
[0004]
[Problem(s) to be Solved by the Invention] Although such a hard carbon film was formed of various PVD and various CVD, the adhesion of a DLC film and a base material was bad, and since a friction property was moreover inferior, when the load became large at the time of use, it had the problem that frictional force increased and ablation arose. Moreover, since the difference of the coefficient of thermal expansion of a base material and a DLC film was large, internal stress occurred on the DLC film after DLC film formation, and there was a problem that ablation arose.
[0005] The purpose of this invention is to offer the moving part which solved the above-mentioned problem, and its manufacture method.
[0006]
[Means for Solving the Problem] The moving part by this invention is a moving part in which the hard carbon film is formed on the surface of the base material, and the mixolimnion of a carbon atom and a pouring atom is formed in the interface portion of a base material and a hard carbon film.
[0007] The manufacture method of the moving part by this invention is a method of manufacturing the moving part in which the hard carbon film is formed on the surface of the base material, after it forms a hard carbon film, pours in ion with ion-implantation and is characterized by forming the mixolimnion of a carbon atom and a pouring atom in the interface portion of a base material and a hard carbon film by this.
[0008] In this method, a hard carbon film is a DLC film and the formation is performed by various PVD and various CVD as usual.
[0009] The manufacture method of other moving parts by this invention is a method of manufacturing the moving part in which the hard carbon film is formed on the surface of the base material, and as soon as it forms a hard carbon film, it pours in ion with ion-implantation and it is characterized by forming the mixolimnion of a carbon atom and a pouring atom in the interface portion of a base material and a hard carbon film by this by it.
[0010] In this method, a hard carbon film is a DLC film and it is good to perform the formation by the ion plating method or the vacuum deposition method. It is because these methods become possible [carrying out in a high vacuum] and it becomes easy to carry out simultaneously with pouring of ion.
[0011] Moreover, as for the acceleration voltage in the case of the ion implantation of inert gas, in the two above-mentioned methods, it is good that they are 10 or more keVs. Because, although it is because a spatter phenomenon occurs and the pouring depth does not become large in less than 10 keVs, when sufficient ion implantation to the interior is taken into consideration, this acceleration voltage is 50 or more keVs especially preferably.
[0012]
[Function] If the mixolimnion of a carbon atom and a pouring atom is formed in the interface portion of a base material and a hard carbon film, while the adhesion of a base material and a hard carbon film will improve, a friction property improves. Moreover, the difference of the coefficient of thermal expansion of a base material and a hard carbon film is absorbed by the mixolimnion.
[0013] After forming a hard carbon film, ion is poured in with ion-implantation. How to form the mixolimnion of a carbon atom and a pouring atom in the interface portion of a base material and a hard carbon film by this, And as soon as it forms a hard

carbon film, ion is poured in with ion-implantation, and according to the method of forming the mixolimnion of a carbon atom and a pouring atom in the interface portion of a base material and a hard carbon film by this, the moving part mentioned above can be manufactured easily.

[0014]

[Example] Hereafter, the example of this invention is explained with reference to a drawing.

[0015] Drawing 1 expands and shows a part of moving part by this invention.

[0016] It is the base material (1) which a moving part becomes from stainless steel in drawing 1 . It is a DLC film (2) to a front face. It is formed and is a base material (1). DLC film (2) To an interface portion, it is a DLC film (2). Carbon atom to constitute (3) Pouring atom (4) Mixolimnion (5) It is formed. In addition, (6) Base material (1) The atom to constitute is shown. Base material (1) It sets to a surface layer and is a DLC film (2). Carbon atom to constitute (3) A part and pouring atom (4) It has entered in the base material (1).

[0017] The equipment used for drawing 2 manufacturing a moving part is shown.

[0018] It is fundamentally the same as that of an ion plating system, and the equipment shown in drawing 2 is a vacuum chamber (10), an electron beam evaporation source (11), the ionization section (12), and a base material (1). It has the base-material supporter material (13) supported in the state where it inclined 45 degrees. Moreover, base material attached in the vacuum chamber (10) at base-material supporter material (13) (1) The ion accelerator (14) which irradiates an ion beam is prepared.

[0019] It is a base material (1) about the carbon evaporated from the evaporation source (11) while rotating a base material (1) by using such equipment and rotating base-material supporter material (13). As soon as it carries out vacuum evaporationo, for example, nitrogen ion is poured in by the ion accelerator (14), and a moving part is manufactured by forming a DLC film (2).

[0020] Moreover, it is a base material (1) about the carbon evaporated from the evaporation source (11) when using the equipment shown in drawing 2 . For example, nitrogen ion is poured in by the back ion accelerator (14) which carried out vacuum evaporationo, and it is a DLC film (2). A moving part is manufactured also by forming.

[0021] Other equipments used for drawing 3 manufacturing a moving part are shown.

[0022] It is fundamentally the same as that of a vacuum evaporation system, and the equipment shown in drawing 3 is a vacuum chamber (20), an evaporation source (21), and a base material (1). It has the base-material supporter material (22) supported in the state where it inclined 45 degrees. Moreover, base material attached in the vacuum chamber (20) at base-material supporter material (22) (1) The ion accelerator (23) which irradiates an ion beam is prepared.

[0023] It is a base material (1) about the carbon evaporated from the evaporation source (21) while rotating a base material (1) by using such equipment and rotating base-material supporter material (22). As soon as it carries out vacuum evaporationo, for example, nitrogen ion is poured in by the ion accelerator (23), and a moving part is manufactured by forming a DLC film (2).

[0024] Moreover, it is a base material (1) about the carbon evaporated from the evaporation source (21) when using the equipment shown in drawing 3 . For example, nitrogen ion is poured in by the back ion accelerator (23) which carried out vacuum evaporationo, and it is a DLC film (2). A moving part is manufactured also by forming.

[0025] Next, the concrete example of this invention is explained with the example of comparison.

[0026] While using the equipment shown in example 1 drawing 2 , the graphite was used as quality of an emission. And base material which consists of an Si wafer (1) It attaches in base-material supporter material (13), and is a base material (1). It is a base material (1) about the carbon which evaporated from the evaporation source (11) while making it rotate. As soon as it carries out vacuum evaporationo, nitrogen ion is poured in by the ion accelerator (14), and it is a DLC curtain (2). It formed. Membrane formation conditions are degree of vacuum 10-4Torr in a vacuum chamber (10), time 10min, 100mA of emission currents, and -1.0kV of bias voltage. In addition, ion plating conditions are 1kV in filament current 14A and bombardment voltage, and ion-implantation conditions are acceleration energy 150keV and dose 2.5E16ions.

[0027] While using the equipment shown in example 2 drawing 2 , the graphite was used as quality of an emission. And base material which consists of an Si wafer (1) It attaches in base-material supporter material (13), and is a base material (1). It is a base material (1) about the carbon which evaporated from the evaporation source (11) while making it rotate. After carrying out vacuum evaporationo, nitrogen ion is poured in by the ion accelerator (14), and it is a DLC film (2). It formed. Membrane formation conditions are degree of vacuum 10-4Torr in a vacuum chamber (10), time 10min, 100mA of emission currents, and -1.0kV of bias voltage. In addition, ion plating conditions are 1kV in filament current 14A and bombardment voltage, and ion-implantation conditions are acceleration energy 150keV and dose 2.5E16ions.

[0028] While using the equipment shown in example 3 drawing 3 , the graphite was used as quality of an emission. And base material which consists of an Si wafer (1) It attaches in base-material supporter material (22), and is a base material (1). It is a base material (1) about the carbon which evaporated from the evaporation source (21) while making it rotate. As soon as it carries out vacuum evaporationo, nitrogen ion is poured in by the ion accelerator (23), and it is a DLC film (2). It formed. Membrane formation conditions are degree of vacuum 10-4Torr in a vacuum chamber (20), time 10min, and 100mA of emission currents. In addition, ion-implantation conditions are acceleration energy 150keV and dose 2.5E16ions.

[0029] While using the equipment shown in example 4 drawing 3 , the graphite was used as quality of an emission. And base material which consists of an Si wafer (1) It attaches in base-material supporter material (22), and is a base material (1). It is a base material (1) about the carbon which evaporated from the evaporation source (21) while making it rotate. After carrying out vacuum evaporationo, nitrogen ion is poured in by the ion accelerator (23), and it is a DLC film (2). It formed. Membrane formation conditions are degree of vacuum 10-4Torr in a vacuum chamber (20), time 10min, and 100mA of emission currents. In addition, ion-implantation conditions are acceleration energy 150keV and dose 2.5E16ions.

[0030] While using the equipment shown in example of comparison 1 drawing 2 , the graphite was used as quality of an emission. And base material which consists of an Si wafer (1) It attaches in base-material supporter material (13), and is a base material (1). It is a base material (1) about the carbon which evaporated from the evaporation source (11) while making it rotate. Vacuum evaporationo is carried out and it is a DLC curtain (2). It formed. Membrane formation conditions are degree of vacuum 10-4Torr in a vacuum chamber (10), time 10min, 100mA of emission currents, and -1.0kV of bias voltage. In addition, ion plating conditions are 1kV in filament current 14A and bombardment voltage.
[0031] While using the equipment shown in example of comparison 2 drawing 3 , the graphite was used as quality of an emission. And base material which consists of an Si wafer (1) It attaches in base-material supporter material (22), and is a base material (1). It is a base material (1) about the carbon which evaporated from the evaporation source (21) while making it rotate. Vacuum evaporationo is carried out and it is a DLC film (2). It formed. Membrane formation conditions are degree of vacuum 10-4Torr in a vacuum chamber, time 20min, and 100mA of emission currents.
[0032] DLC film of the moving part manufactured in examples 1-4 and the examples 1-2 of comparison (2) In order to evaluate a performance, the fine oscillating scratch examination by the diamond indenter was performed, and it asked for the relation between a load and frictional force. The result is shown in drawing 4 .
[0033] It is a DLC film (2) at the time of use that frictional force becomes large in drawing 4 . A bird clapper is expressed that destruction tends to take place. It sets to drawing 4 and is the DLC film (2) of examples 1 and 2. A performance is the DLC film (2) of examples 3 and 4. It is thought that the performance is excelled because according to the ion plating method an evaporation atom can be ionized, it can accelerate electrically and a base material can be made to carry out collision adhesion.
[0034] The 1st as shown in drawing 5 and drawing 6 , respectively from example 5 and example of comparison 3-4SUS440C, and the 2nd two cylinder-like base material (30) and (31) were built. The 1st base material (30) shown in drawing 5 is 10mm in the outer diameter of 30mm, the bore of 10mm, and length, and beveling is performed to the both ends of a periphery side. The 2nd base material (31) shown in drawing 6 is 10mm in the outer diameter of 30mm, the bore of 10mm, and length, and is a flat side (31a) with a width of face of 0.7mm to the center section of the length of a periphery side. It is formed and the diameter of the both sides is gradually reduced toward the edge. And two moving parts which formed the DLC film like the case of the example 1 mentioned above to the periphery side of both base materials (30) and (31) (example 5), Two moving parts which formed the DLC film like the case of the example 1 of comparison mentioned above to the periphery side of both base materials (30) and (31) (example 3 of comparison), Two moving parts (example 4 of comparison) which do not form the DLC film in the periphery side of both base materials (30) and (31) are prepared, and 2 ****** use a **-slip-test machine, and it was made to rotate, contacting two moving parts, an example 5 and the examples 3-4 of comparison, mutually, as shown in drawing 7 . The rotational frequency of the moving part [rotational frequency / of the moving part using the 1st base material (30)] using 600rpm and the 2nd base material (31) was set to 580rpm, it rolled considering the slip factor as 3.3%, - slip test was performed, and change of the friction torque accompanying time progress and the amount of raising dust were investigated. Change of the friction torque of an example 5 and the examples 3-4 of comparison is shown in drawing 8 , the amount of raising dust of an example 5 is shown in drawing 9 , and the amount of raising dust of the example 4 of comparison is shown in drawing 10 , respectively.
[0035] Although nitrogen is mentioned as pouring ion in the above-mentioned example, it cannot be overemphasized that the effect that inert gas, such as an argon, titanium, carbon, boron, etc. are the same is acquired.
[0036]
[Effect of the Invention] Since according to the moving part of this invention a friction property improves as mentioned above while the adhesion of a base material and a hard carbon film improves compared with the conventional thing, even if a load becomes large at the time of use, frictional force does not increase, but exfoliation of a hard carbon film is prevented. Moreover, since the difference of the coefficient of thermal expansion of a base material and a hard carbon film is absorbed by the mixolimnion, the exfoliation is prevented when internal stress occurs on a hard carbon film after hard carbon film formation.
[0037] Moreover, according to the two methods of this invention, the moving part which has an effect which was mentioned above can be manufactured easily.

[Translation done.]

* NOTICES *

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is drawing expanding and showing a part of moving part by this invention.
[Drawing 2] It is drawing showing the outline composition of the equipment which manufactures a moving part.
[Drawing 3] It is drawing showing the outline composition of other equipments which manufacture a moving part.
[Drawing 4] It is the graph with which the result of a performance-evaluation examination of the moving part of examples 1-4 and the examples 1-2 of comparison is shown, and the relation between a load and frictional force is expressed.
[Drawing 5] It is partial drawing of longitudinal section showing the 1st base material used for the moving part of an example 5 and the examples 3-4 of comparison.
[Drawing 6] It is partial drawing of longitudinal section showing the 2nd base material used for the moving part of an example 5 and the examples 3-4 of comparison.
[Drawing 7] It is the side elevation showing the evaluation test method of the moving part of an example 5 and the examples 3-4 of comparison.
[Drawing 8] It is the graph which shows change of the friction torque accompanying time progress of the moving part of an example 5 and the examples 3-4 of comparison.
[Drawing 9] It is the graph which shows the amount of raising dust accompanying time progress of the moving part of an example 5.
[Drawing 10] It is the graph which shows the amount of raising dust accompanying time progress of the moving part of the example 4 of comparison.
[Description of Notations]
1 Base Material
2 DLC Film (Hard Carbon Film)
3 Carbon Atom
4 Pouring Atom
5 Mixolimnion
30 Base Material
31 Base Material

[Translation done.]

* NOTICES *

1. This document has been translated by computer.So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] The moving part which is a moving part in which the hard carbon film is formed on the surface of the base material and by which the mixolimnion of a carbon atom and a pouring atom is formed in the interface portion of a base material and a hard carbon film.
[Claim 2] The manufacture method of the moving part characterized by being the method of manufacturing the moving part in which the hard carbon film is formed on the surface of the base material, pouring in ion with ion-implantation after forming a hard carbon film, and forming the mixolimnion of a carbon atom and a pouring atom in the interface portion of a base material and a hard carbon film by this.
[Claim 3] The manufacture method of the moving part characterized by pouring in ion with ion-implantation and forming the mixolimnion of a carbon atom and a pouring atom in the interface portion of a base material and a hard carbon film by this as soon as [are the method of manufacturing the moving part in which the hard carbon film is formed on the surface of the base material, and] it forms a hard carbon film.

[Translation done.]